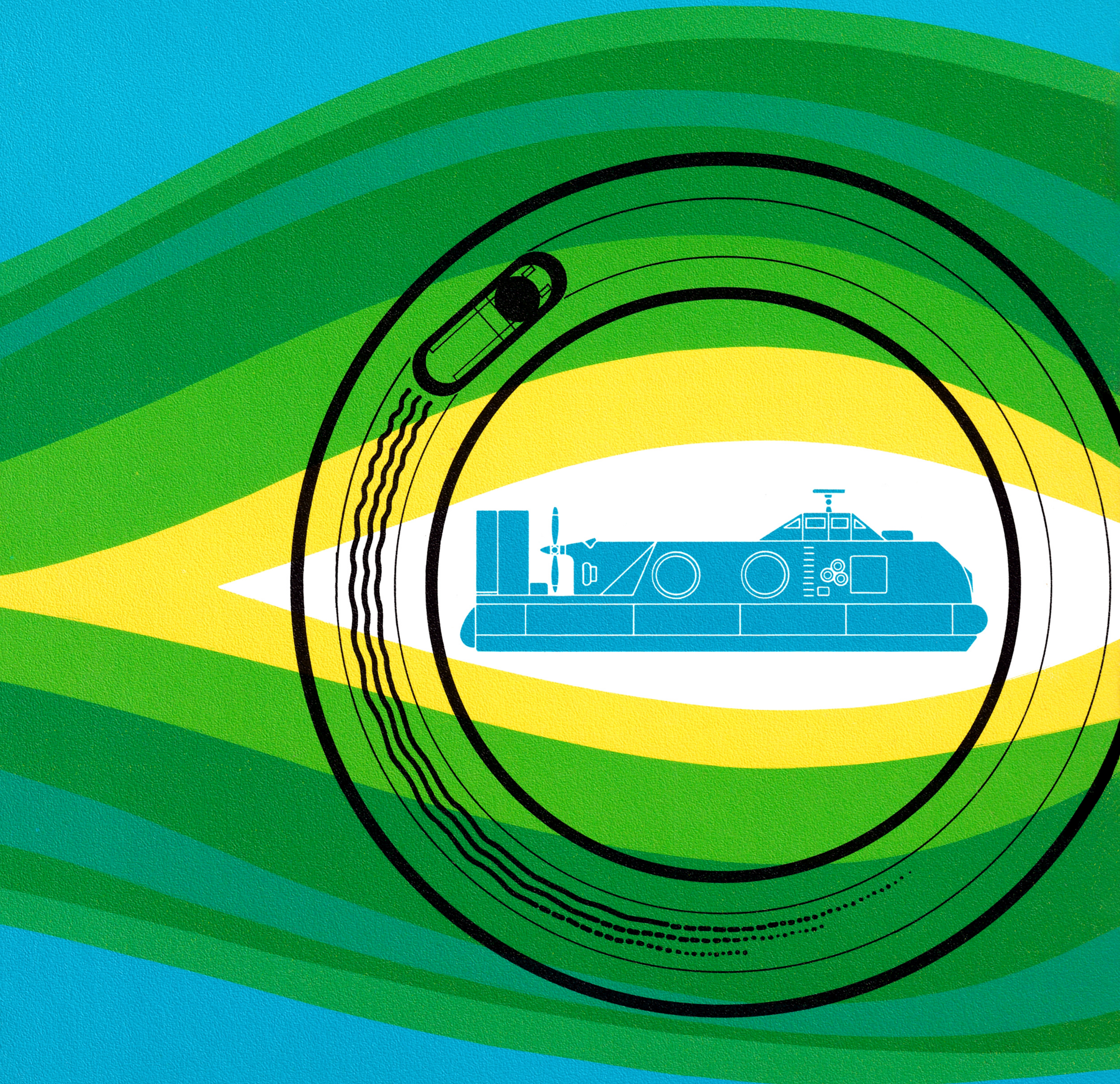


rendezvous

MAY 1968

PUBLISHED BY BELL AEROSYSTEMS COMPANY

AIR CUSHION RESEARCH



rendezvous[®]

Vol. VII / No. 3 / 1968

*Rendezvous is published bi-monthly by the Public Relations Department,
Charles F. Kreiner, Director;
Donald J. Norton, Editor; E. W. Donovan II, Art Director.*

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COVER: E. W. Donovan II
visualizes a tethered
skimmer test in Bell's
new Air Cushion Tech-
nology Laboratory.

THE newsman and a magazine writer locked arms, waved at the crowd and marched bravely toward the iron-gray spaceship.

In a few minutes they were checked out on the instruments, strapped themselves in and quietly awaited the countdown. Swiftly, the cockpit was filled with the roar of giant first-stage engines. The spaceship shuddered under the force of liftoff.

The flight went smoothly, and the craft rolled slightly as it prepared to go into orbit. Then disaster struck. The ship flipped sharply to the left, jerked back and swiveled in a crooked arc. Outside, stars swirled like a tentful of fireflies.

"Jeepers!" shouted the newsman.

Three minutes later the craft was quiet again, and the two men were back on their feet inside Building 5 at the National Aeronautics and Space Administration's Manned Spacecraft Center in Houston, Texas.

Building 5 is where NASA keeps many of its simulators—the elaborate machines that give astronauts the feel of space and help prepare them for the many tasks they will have to perform on a trip to the moon.

The machine that the two writers sampled during a recent press tour is known as the Apollo Crew Station Trainer, which is part of a Dynamic Crew Procedures Simulator (DCPS).

A device formerly used to train Gemini astronauts, the DCPS contains a duplicate of the three-man

cockpit of the Apollo Command Module. Surrounding the CM is a spherical wall, on which a simulated sky is projected.

The CM is fastened to a hydraulic powered moving base that can rotate the mock spacecraft about each of three separate axes. The entire operation, star pattern and CM movements, is controlled by one of many programs of the DCPS computer complex.

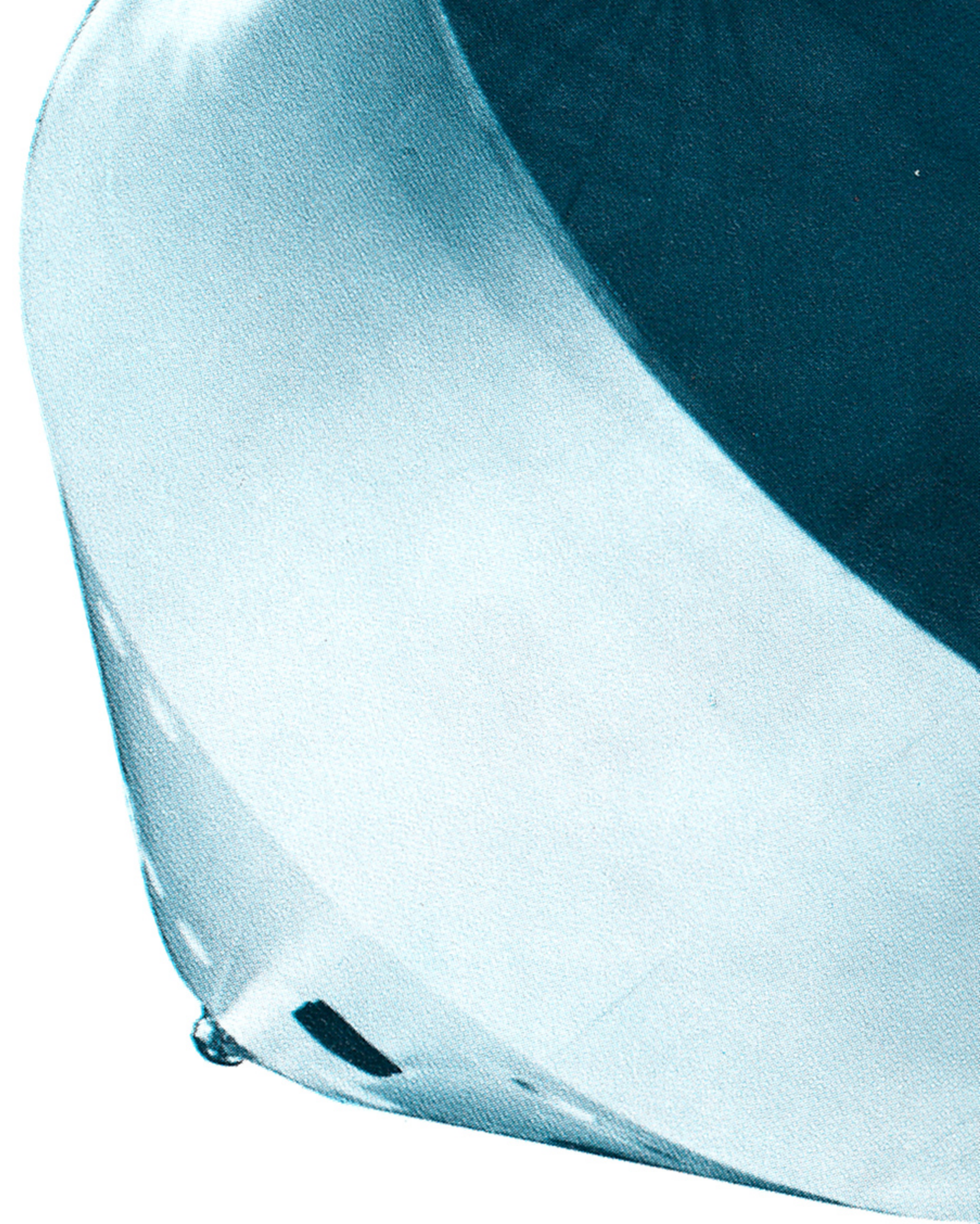
A DCPS instructor can put astronauts into a flight that runs into trouble shortly after liftoff, for example. Or he can call on a program in which the flight is near perfect. Apollo astronauts will "fly" it in all kinds of situations.

When trouble arrives, the astronauts respond by working with computer-operated flight instruments and controls inside the cockpit.

These flight instruments, including meters, digital displays, circuit breakers and switches can be programmed through the DCPS computer complex to simulate an Apollo mission from launch to recovery.

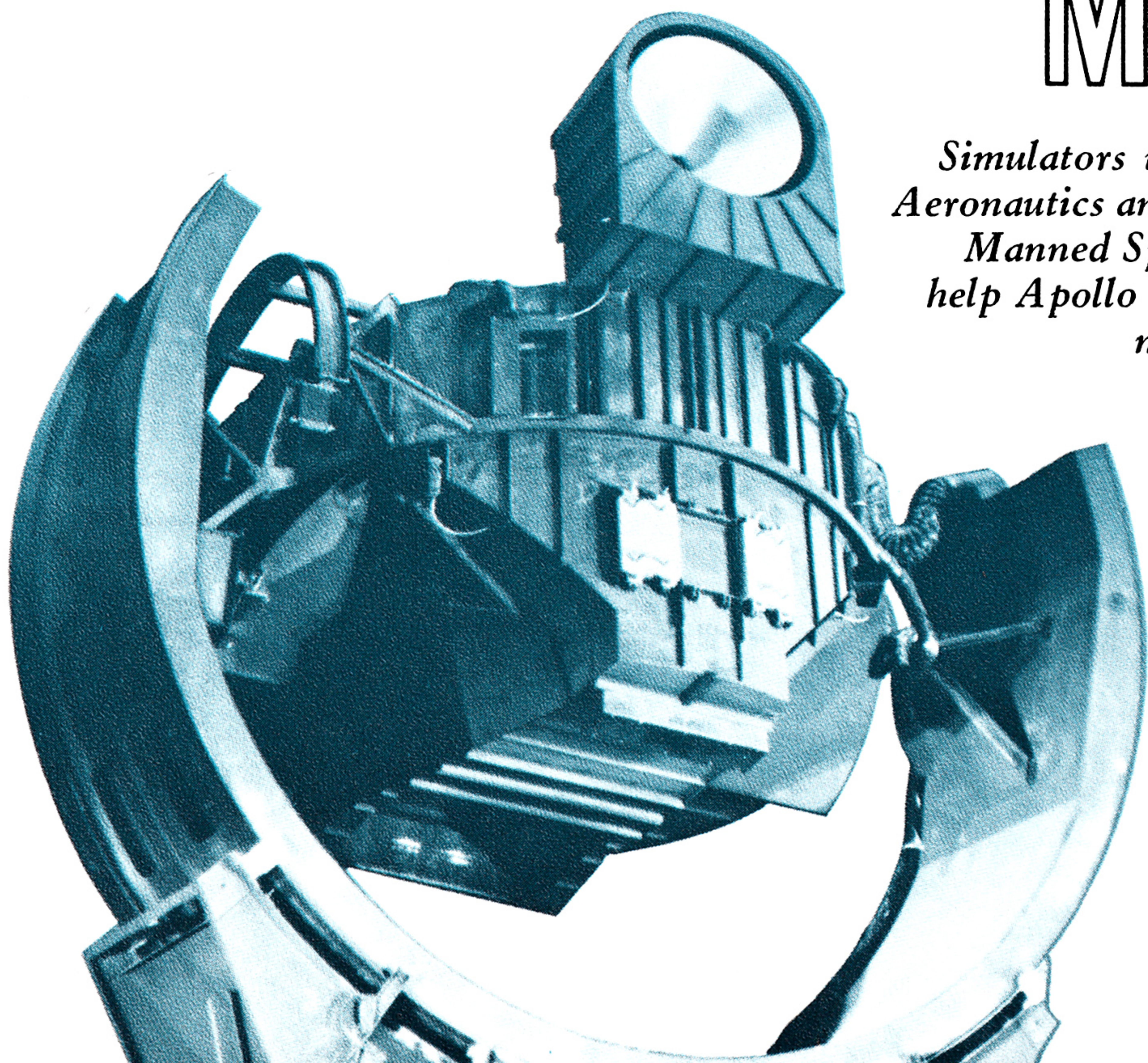
Other simulators in Building 5 use different approaches than the DCPS, and all are effective in simulating the conditions of space.

One of the newest is the Water Immersion Facility, put into opera-



NASA'S MIRACLE MACHINES

Simulators used by the National Aeronautics and Space Administration's Manned Spacecraft Center in Houston help Apollo astronauts train for the biggest navigation job since Columbus: Man's first flight to the moon.



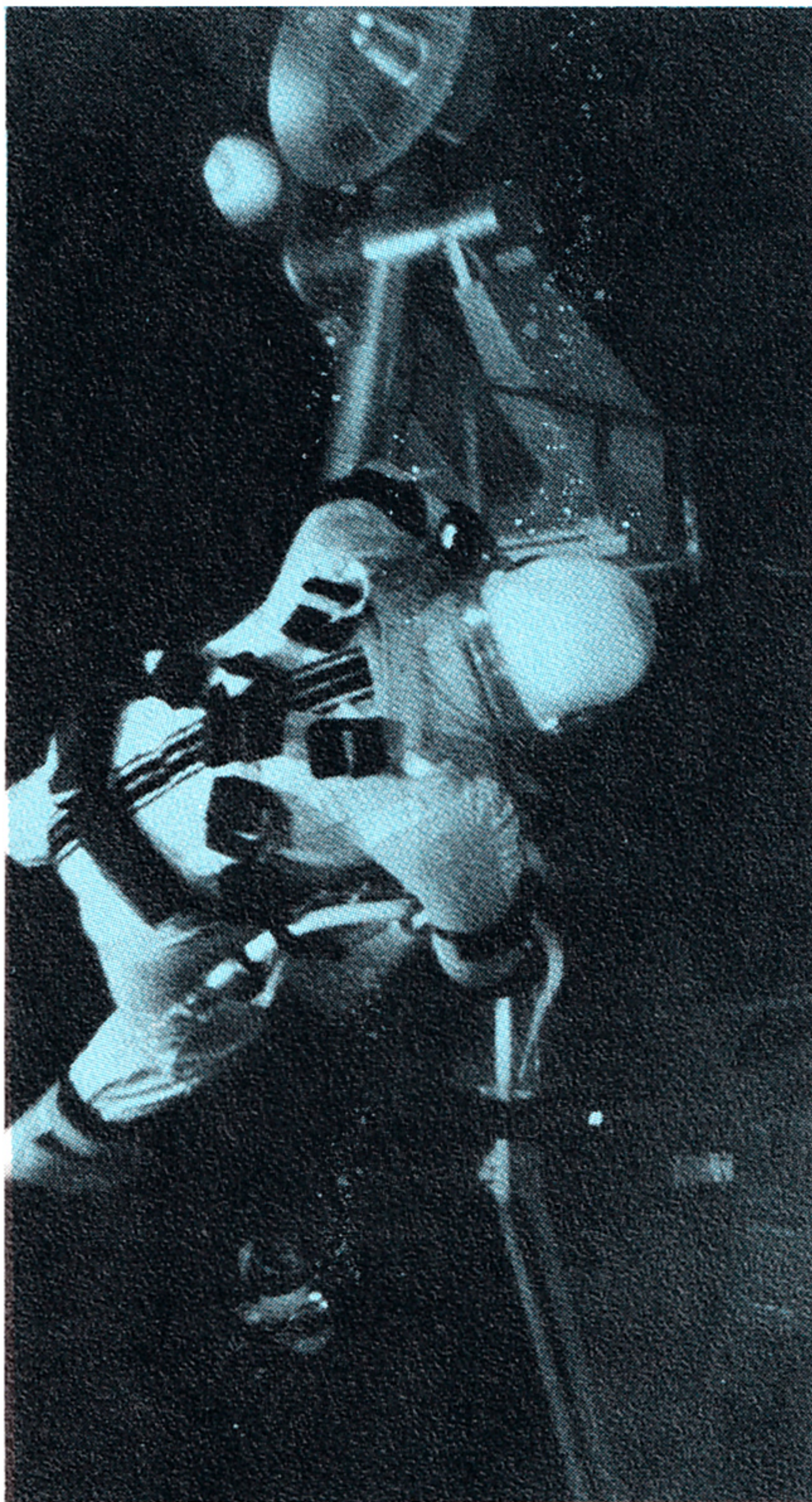
Top: Astronauts William A. Anders, Michael Collins and Frank Borman climb the stairs leading to the Apollo Command Module Simulator. The interior view shows them seated in the module.

Bottom: Television monitors and control panels where Apollo instructors operate simulated space flights.

tion last August 1. In this giant pool, astronauts are weighted for neutral buoyancy to simulate zero gravity or reduced gravity conditions.

The tank is 29 feet 9 inches in diameter and 16 feet deep. It holds about 85,000 gallons of water that is constantly filtered to be crystal clear. An electric heater keeps the water at a constant temperature of 83 degrees.

The tank is also equipped with an underwater communications system that allows two-way conversation between trainees and personnel on the surface. All tests in the facility are recorded on video tape by underwater cameras operated by SCUBA divers.



Dressed in space suits that are connected to the surface by life lines, astronauts in the tank get the feel of working on space vehicles in a zero gravity environment. In addition, procedures for Apollo astronauts are established by using the tank as a rehearsal room.

Another NASA trainer that shows the astronauts how to respond to space conditions is the Translation and Docking Simulator (TDS), a dynamic, life-sized mockup of the

Lunar Module and the Command-Service Module.

The TDS has two moving bases, one each for the LM and CM. These bases simulate the motions of the two spacecraft in orbit with a range separation of 98 feet. The simulation can include approach, physical contact, docking, rigidizing, undocking and maneuvering away.

That is the kind of training the astronauts will need when they ascend from the lunar surface in the LM and must dock and safely enter the CM while in orbit around the moon.

The TDS is designed to simulate the motions of the LM and CM in response to the simulated firings of small rocket thrusters, as the spacecraft would respond to the firing of actual thrusters in orbit.

Except for the feeling of weightlessness, the motion is smooth and the feel is the same as that which would occur in orbit. Solar light is simulated, giving a visual presentation of the light angles and shadows that exist in orbit, and display panels and hand controllers in the spacecraft are identical to the operational vehicles.

The two vehicles maneuvering toward each other put on an impressive show of the complexities of space flight.

A typical training session lasts about 1½ hours. During it, astronauts perform the manual tasks of docking. They view the target vehicle from the spacecraft windows and manipulate hand controllers to maneuver the spacecraft for docking.

During a simulated mission, two astronauts (the command pilot and the systems engineer) stand in the Lunar Module. They are held in a standing position by shoulder straps. A small window is located just above the drough (a dishshaped structure, two feet in diameter, that locks to the Command Module's probe). By tilting his head upwards, the command pilot is able to look out this window and see the docking alignment target on the CM.

On a typical training session, lighting conditions are varied and several malfunctions are simulated. The failures are designed to train the astro-

nauts in the correct procedures to be used in the event of equipment failure. An example of the simulated failures: thrusters that will not fire, will not shut off, or fire intermittently, loss of gyro reference or loss of communications.

Originally built for simulating the rendezvous and docking of Gemini and Agena spacecraft, the TDS was designed so it could be modified to support Apollo and future manned missions.

Two of the most complex trainers in Building 5 are the Apollo Mission Simulator (AMS) and the Lunar Mission Simulator (LMS). The heart of each trainer is a cockpit resembling the actual spacecraft, including all panels, controls, switches and equipment. The essential life-support systems are also simulated, so a full 14-day lunar mission can be practiced realistically.

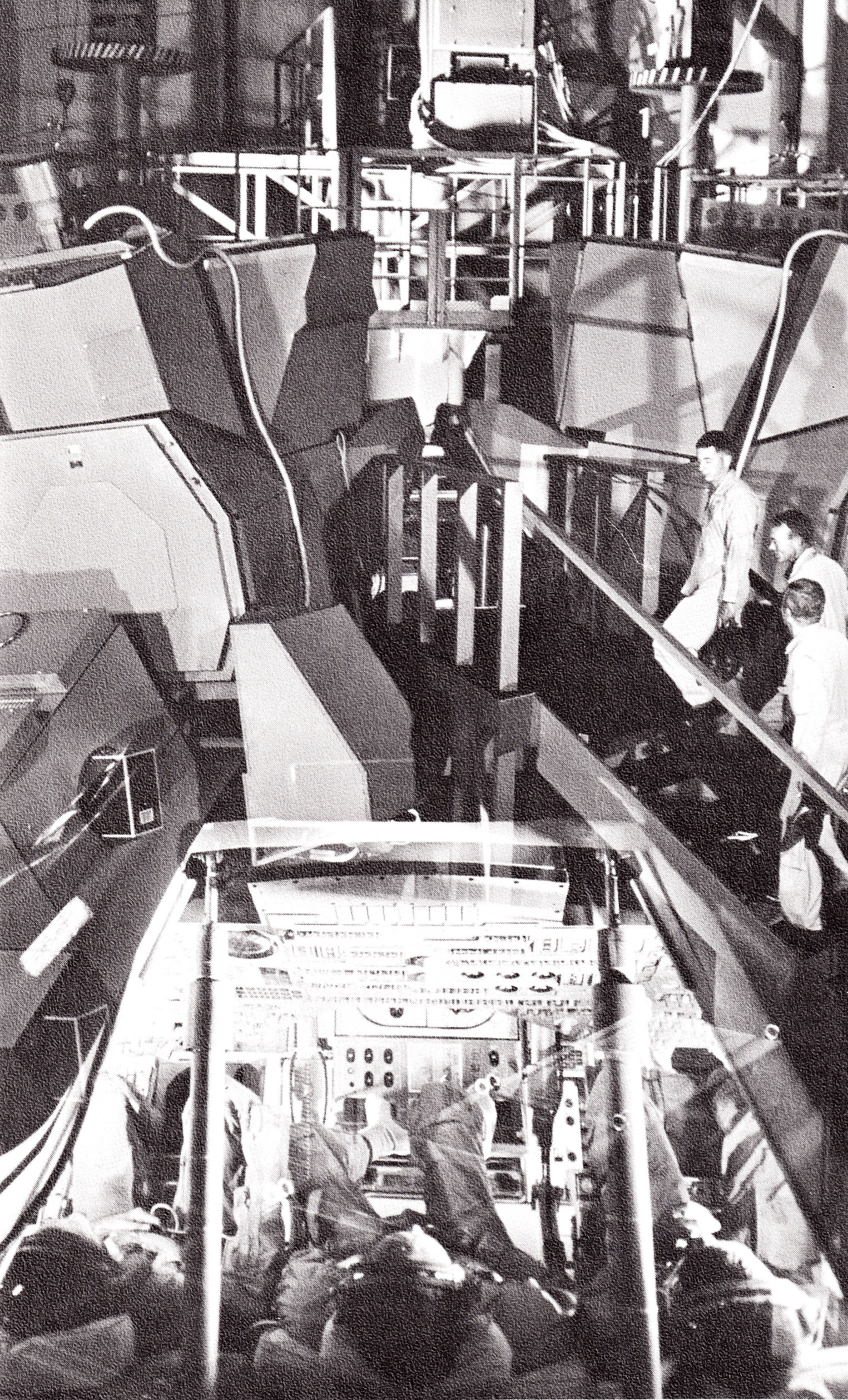
Using AMS and LMS, NASA can simulate the entire mission, beginning at T minus 60 seconds and including all phases: Launch boost, earth orbit, translunar coast, lunar orbit, descent, lunar stay, ascent, rendezvous, docking, transearth coast and reentry. Both visual and acoustical effects are simulated in these trainers; only weightlessness and the gravitational forces of launch and reentry are missing.

Seven computers serve the two simulators. They are programmed to provide normal, emergency and abort flight conditions. More than 1,000 training problems can be inserted into the simulated spacecraft systems. This enables the crew to prepare for nearly every type of emergency situation. The computers also generate telemetry information in actual mission format, for transmission to ground station equipment.

Precise computation of trajectories, orbits and reentry corridors are extremely important to the success of Apollo, and are some of the most exacting aspects of the simulation.

To provide high accuracy, the computers are programmed to determine the effect of even minor variations in earth, sun and moon orbits relative to the projected flight of the spacecraft.

To complete the simulation, the



AMS and LMS are tied in with the Mission Control Center in Houston. Thus, the complete Apollo mission from liftoff to reentry can be realistically simulated.

Surrounding the crew stations, in what one visitor termed "a pileup of wrecked railroad cars," are more than five tons of lenses and curved glass. These provide visual simulation so flight crews can make navigational measurements.

The present AMS and LMS configuration is tailored for the first manned flight. After training needs of that mission have been completed, the two trainers will be updated for future missions.

The procedures that will be needed for Apollo are simulated in two other trainers: the Lunar Module Procedures Simulator and the Command Module Procedures Simulator.

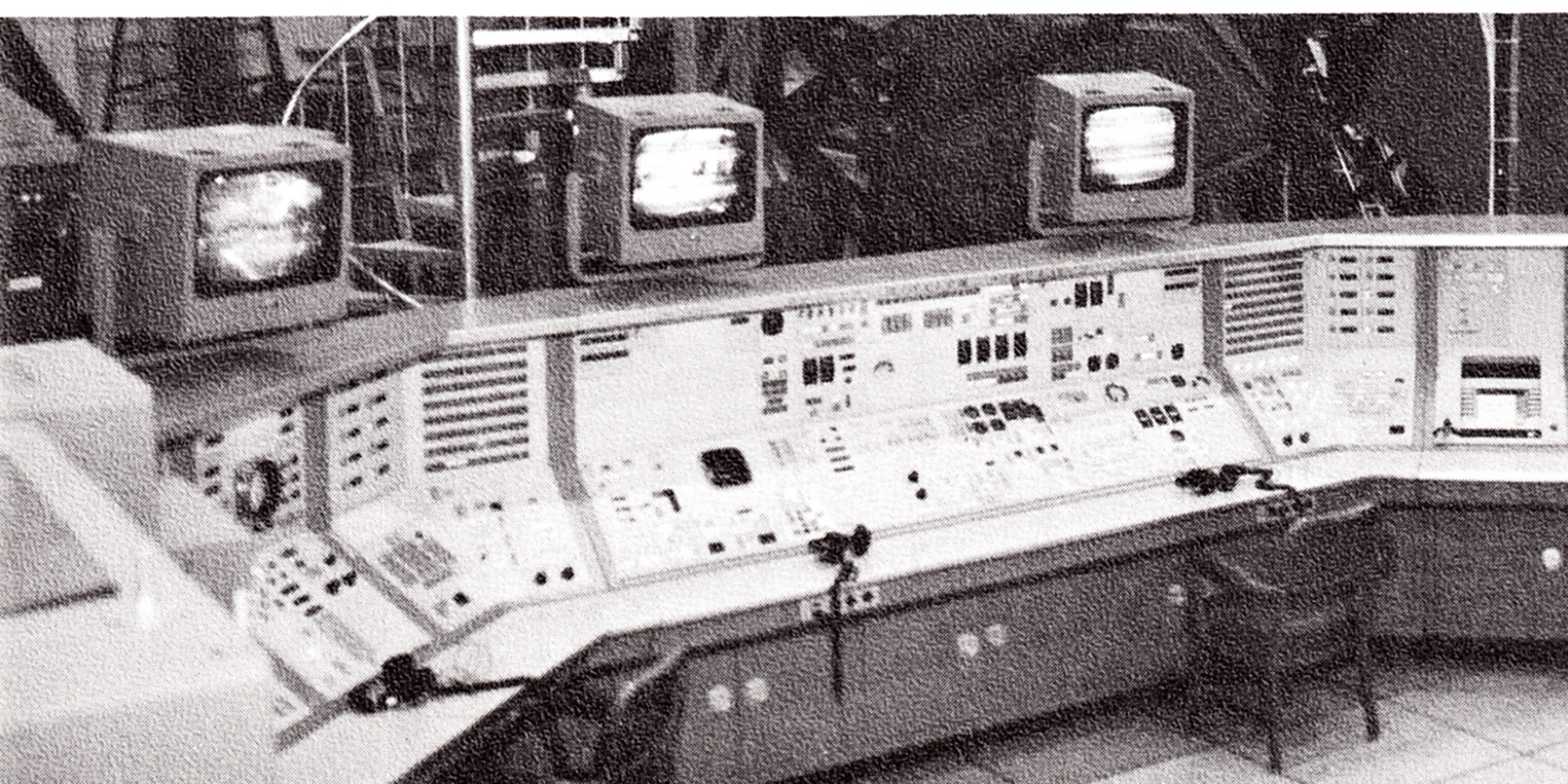
An optical display system built by Bell Aerosystems, known as the Lunar Module Rendezvous Simulator, is an important part of the Lunar Module Procedures Simulator. The Bell equipment gives astronaut trainees the view they will see through the LM windows during rendezvous and docking with the Command Module.

Working with an instructor, flight crews can also go through the procedures of liftoff through reentry, and the instructor is able to insert simulated flight system malfunctions at any time during a training exercise.

Among the few static simulators in Building 5 are full-scale mockups of the Command Module and the Lunar Module. Each is configured to conform to the current mission, and will be reconfigured for each subsequent mission.

In these, the astronauts learn how to get in and out of the vehicles, familiarize themselves with the cockpit interiors and evaluate experimental and operational equipment. The mockups are also used for engineering evaluations by MSC engineers.

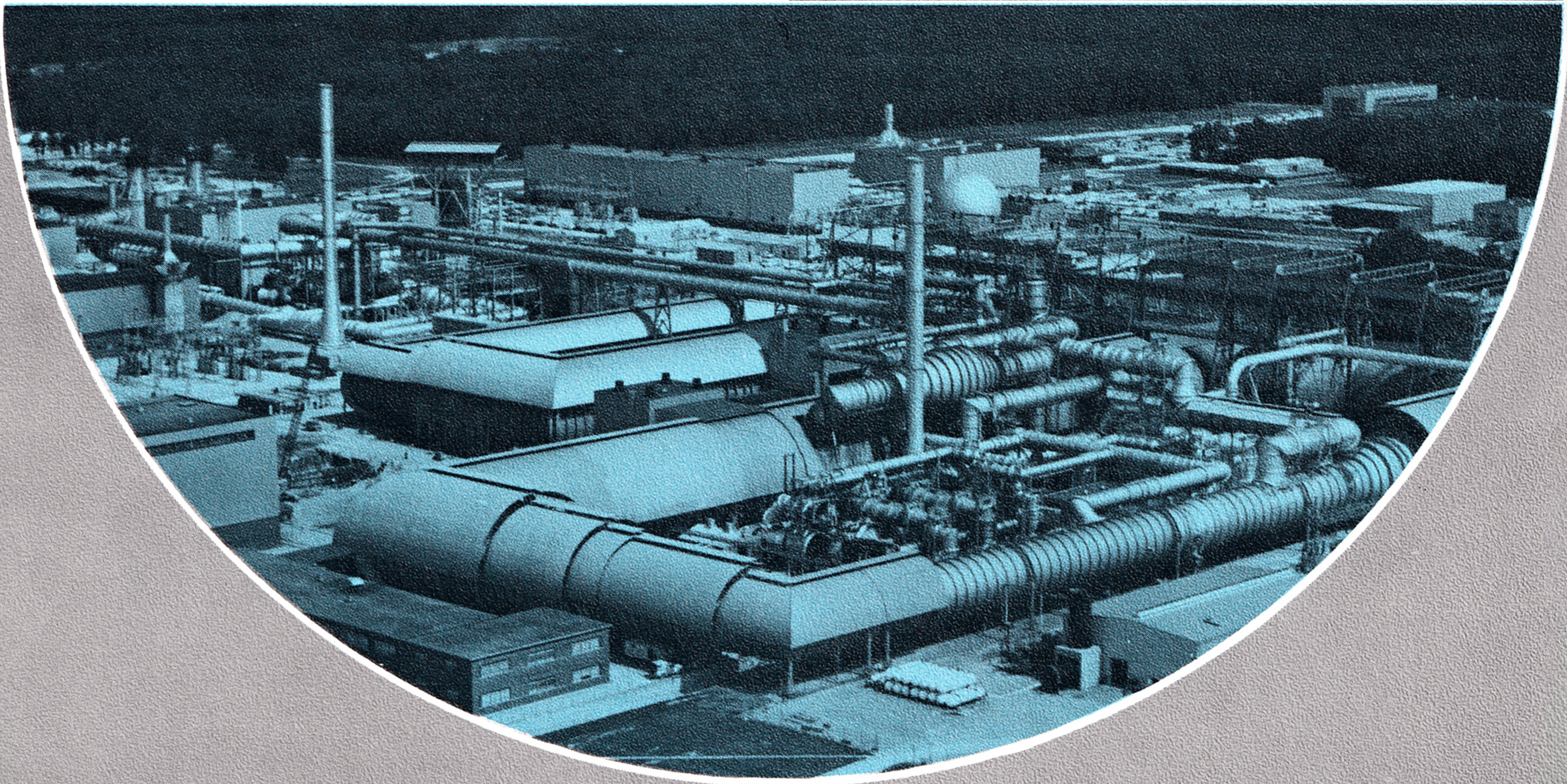
The Lunar Module mockup, or "moon bug," is small compared to the 36-story-high Saturn V that will send the actual LM on its way to the moon. But it is three stories tall itself, and one of the most impressive places at the Manned Spacecraft Center. ■





The United States needs
a long-range plan to develop
its research facilities and test
ranges. In them, the nation's
aerospace future will be born.

Laboratories That Shape The Future...



THE foundations for the future in aerospace are the laboratories, wind tunnels, test ranges and other facilities where today's aerospace fledglings hatch and are pushed from the nest. That is the opinion of Gen. James Ferguson, commander of the Air Force Systems Command, expressed in a recent talk.

Defining aerospace facilities as a "national resource" in the sense that they serve national interests, Gen. Ferguson listed four reasons why he was concerned about their status.

First, he said advanced research and test facilities are "long lead-time items essential to our future preparedness posture."

Second, "until recently, the facilities built 15 to 20 years ago have been adequate, with modifications and additions, to meet our needs. Now, with the advent of the jumbo jets, the supersonic transport (SST), advanced manned space missions, and the possibilities of travel in the hypersonic flight regime, we are stretching present-day facilities to a thin point and reaching a limit in our ability to 'make do' on a year-to-year basis."

Third, there is clear evidence "that the Soviets are emphasizing progressive research, test and technical facilities and that they are taking some giant steps in these directions."

Fourth, the general said the U.S. has "no imaginative, comprehensive, long-range plan for the design, development and acquisition of facilities" that will be needed in the future. He said such a plan is needed, and that it must be national in scope, and time must not be wasted in getting the program going.

"In the first place," he said, "large aerospace facilities and their 'furnishings' are hardly mass-produced items. A highly-advanced, precision test facility may take three to five years to design and develop, and possibly another two or three years to construct.

"For planning purposes, we must add the time required for budget justification and approval, and for funding under military construction appropriations."

He said test facilities must "pace" the state-of-the-art, keeping ahead of research and development programs and staying "a generation" ahead of production requirements.

"Accordingly," he said, "it is virtually impossible to advocate a major new facility on the strength of a specific future program, for in many

cases the facility must exist before the technologies necessary to the program can be identified."

Thus, facilities must precede programs, and the general noted that historically, new facilities are seldom used for, or confined to, the purposes for which they were intended.

"The Central Inertial Guidance Test Facility at Holloman Air Force Base, New Mexico, for instance," he said, "was first designed for the testing of gyroscopes." Along with the seven-mile, high-speed sled track, also at Holloman, the guidance facility has since proven to be indispensable in the development of ballistic missiles and both are now used



General Ferguson became commander of the Air Force Systems Command on September 1, 1966, following the retirement of General B. A. Schriever. He came to the command from a five-year assignment in the pentagon as air force deputy chief of staff for Research and Development. A former vice commander of AFSC, General Ferguson has 32 years military service including broad command experience. In Europe during World War II, he was air controller during the Normandy invasion and served in various campaigns until the German surrender. From 1950 to 1952 he saw duty in the Far East, most of that time as vice commander of the Fifth Air Force in Korea. His decorations include the distinguished service medal, legion of merit, distinguished flying cross, bronze star medal, and air medal.

for testing inertial navigation systems for aircraft (such as the F-111 avionics package) for testing terminal seekers used on air-to-ground missiles, and for a variety of other purposes. The sled track has proven especially versatile. Only about 15 per cent of its utilization today is in support of guidance tests.

The cost of the Holloman facility: \$42-million, which was more than paid off by its contributions to the ballistic missile program.

"The launch of the first Minuteman ICBM was completely successful," he said. "Yet, any one of the six deficiencies first detected in the Holloman tests of the guidance system could have caused it to fail."

Another example: Gen. Ferguson said a NASA spokesman recently told the Air Force that a test program conducted by the Air Force's

Arnold Engineering Development Center, Tennessee, on the giant J-2 rocket engine gave NASA the final measure of confidence it needed to go ahead with the first Saturn flight test last November.

"These facilities cost a few millions of dollars," said Ferguson. "Consider what the costs would be of a single Saturn flight failure."

As another part of the value of large test facilities to the nation, the general said they have given American industry an "unbiased proving ground where their products and technologies can get objective testing, and enable firms to compete according to common performance standards and conditions."

He said the problem of timely acquisition of facilities "is becoming critical. The resources so useful to the nation today must be assured for tomorrow.

"Unfortunately, while many of yesterday's test facilities were relatively simple and inexpensive, those needed for today and tomorrow tend to be costly and complex—in many instances, more costly and complex than the systems they produce.

"An example is the space suit. To test a comparatively inexpensive space suit we must have an environmental chamber capable of simulating the conditions encountered in space."

Gen. Ferguson said it might be better to view the complexities of test facilities not as penalties of our technological success, but as "opportunities" as the springboard for new generations of progress.

The possible alternative is a United States with an "Achilles heel," with the ideas, the technologies and the needs clearly apparent but without the means to prove or disprove our technical theories."

The general earlier had pointed to Germany as a nation that used its test facilities well. He quoted the late Dr. Theodore von Karman—a leader of technological progressiveness—as follows:

"After World War II, von Karman reported that the substantial German technical progress was 'not the result of any superiority in their personnel or engineering competence, but rather was due to the very substantial support enjoyed by their research institution in obtaining expensive research equipment, such as large supersonic wind tunnels, many years before such facilities were even planned in this country!'" ■

BELL Aerosystems' reliability is being built into Minuteman, the potent intercontinental ballistic missile that stands as one of the nation's chief deterrents against nuclear attack.

Development of an attitude control system for Minuteman has been a two-year project filled with challenges for Bell. Its engineers turned the challenges into a backlog of achievement under the direction of John H. van Lonkhuyzen, a cold executive who has been with the company from the start of the space age.

As vice president-Minuteman Program, van Lonkhuyzen—widely known as merely "Van"—has led a team of about 800 skilled employees in the development of Minuteman's attitude control system. He is proud of the problems overcome by the Bell Minuteman team, and talks about the program with the enthusiasm of an artist for his creation.

"We've pretty well got the design

buttoned down," said van Lonkhuyzen. "All the technical hurdles are past, although we still have a considerable amount of engineering work ahead of us."

He said the first system will be delivered to the Air Force's Eastern Test Range at Cape Kennedy, Florida, in preparation for the first flight of Minuteman III.

Bell is developing the system under contracts with Autonetics Division, North American Rockwell Corp., that will total more than \$100-million by 1970. Van Lonkhuyzen said production contracts have not yet been negotiated.

"One of the most challenging parts

of this program," he said, "has been the new manufacturing techniques it requires." Among the new techniques: Bell specialists had to explore methods of machining columbium, a rare metal. They developed techniques in electron discharge machining—in which holes are drilled by sparks—electron beam welding and astro-arc welding, an automatic fusion welding system.

The Minuteman requires unusual manufacturing techniques because it is a rocket designed to remain flight ready for many years before called upon to go into action. That means the fuel and oxidizer tanks in a system like Bell's must be welded shut at the factory—to be popped open only when needed in flight.

"As managers," he said, "we know what the program's costing us through the use of a system of 'earned value reports'." Under this system, not new to Bell but expanded and perfected in the Minuteman program,

Bell's



every task on the project is assigned a budget, and managers compare the planned figure with the actual. Bell's program has 500 of these tasks.

Van Lonkhuyzen said extremely precise management and manufacturing methods are required by Minuteman. The reason — Minuteman cannot be test flown. It is built and put in a concrete silo. "If the time comes to push the button," said van Lonkhuyzen, "it had better work. There may be no second chance."

He was appointed to the Minuteman program in 1966. Before then, he served as vice president-project and systems management. He joined Bell in 1942 as an aerodynamicist on the P-59—the nation's first jet airplane—and later was involved in the development of the X-1, the world's first supersonic airplane.

In 1946, he attended Massachusetts Institute of Technology to perform company-sponsored study and research on missile control systems,

and eventually became chief of guided missile projects for the company. In 1952, he was named chief of Engineering Technical Departments which were responsible for all development activity in the fields of aerodynamics, structures, dynamics, electronics, servomechanisms and rocket propulsion.

Later, van Lonkhuyzen was manager of Bell's Avionics Division, was named a vice president in 1960 and continued to manage Avionics until 1964. He holds a masters degree from the University of Michigan, and held teaching positions at Michigan State and Brown Universities before coming to Bell. Most of his secondary and early college education was in the Netherlands where he lived for several years after attending primary schools in the U. S.

Off the job, van Lonkhuyzen is handling a number of community tasks. He was vice chairman of the 1967 campaign of the United Fund

of Niagara Falls.

One of his favorite places is Niagara County Community College, where he serves as chairman of the board of trustees. The college was started in 1962 as part of the State University of New York.

In his parish, St. Paul's Methodist Church, he is a trustee and chairman of the finance committee.

He and his wife, Gene, have two children, Rick, a sophomore in Calvin College, Grand Rapids, Mich., and Caryl, who will be a freshman at Kalamazoo (Mich.) College this Fall.

With family activities, the demands of one of Bell's top management positions, regular flights to California and volunteer work for his church, the college and community, van Lonkhuyzen has little time left over for one of his favorite hobbies: Fishing.

"For the time being," he said, "the fishing tackle's getting a little rusty." ■

Minuteman





LONG before the first Bell SK-10 rises up on its skirt and skims away, a model of the giant craft will have proven itself on the waters and test stands at Bell Aerosystems' new Air Cushion Vehicle Technology Laboratory.

First put into operation late last year, the lab is humming with activity this spring. A wide range of equipment unique to air cushion vehicles — from rubber skirts to puff ports — is under test at the lab. And scale models of the SK-10, the Air Cushion Landing Gear (ACLG) and other Bell products are being put through research hurdles there.

One of only a few laboratories in the world that is devoted exclusively to ACV research, the one-story facility, which measures 240 by 117 feet, is dominated by a 100-foot square maneuvering tank. A wavemaking machine can stir up a scale tempest for model ACVs at one end of the tank, and can produce pounding surf at the other end to let vehicles simulate skimming their way onto and off the beach.

"We're proud of this lab," said E. Vernon Griffith, ACV Laboratory test director. "It is very useful in

doing preliminary research work on new ACV concepts." More detailed qualitative testing, once the groundwork is laid at Bell's lab, is presently being carried out under contract in larger and more elaborate facilities, such as the U.S. Naval Ship Research and Development Center.

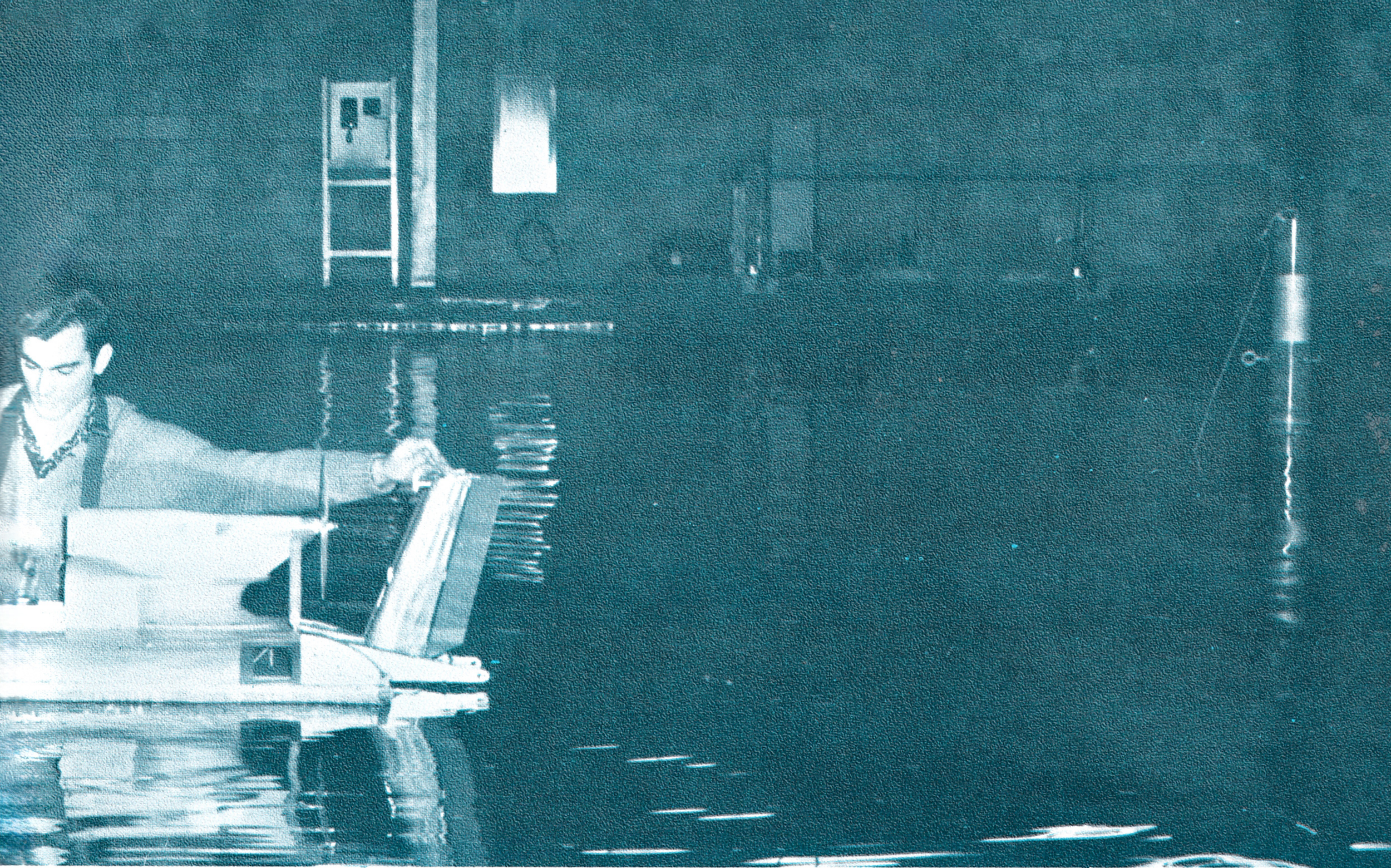
Said John B. Chaplin, Bell's technical director of ACV programs: "Our lab is designed for maximum flexibility, and quick testing of new ideas. If the idea's no good, we know right away, without having to rent a costly out-of-town facility for two weeks — only to realize on the first day that we won't need it until a better idea comes along."

The lab has already proven its worth in the early development of the SK-10. Working with a 1/12th scale model (one inch represents one foot), the ACV test crew has developed several modifications and improvements from the original design. In particular, the geometry of its flexible skirt system has undergone a number of changes from the original design.

The SK-10 will be a giant ACV, measuring 80 feet long and having a normal gross weight of nearly 150

AIR CUSHION RESEARCH

Bell Aerosystems' new Air Cushion Vehicle Technology Laboratory hums with activity as it advances its research program in the field of transportation.



ON RESEARCH

**Air Cushion Vehicle Tech-
with activity as the company
ram in this developing field**

tons. A military ship, the SK-10 will be able to carry 500 troops or 60 tons of payload at speeds up to 80 knots. It is presently being developed by Bell, and has just entered the model testing stage.

Although they look like toys, ACV test models are very costly. The lab's 1/8th-scale SK-5, for example, cost \$12,000, and the final price tag has not yet been put on the SK-10. "Models that are truly scale in weight, shape and detail take thousands of hours of painstaking work to put together," said Griffith. "These models are built by true craftsmen, and provide an extremely accurate rehearsal for the full-sized craft."

The models are built by Bell, in the Wheatfield plant model shop, under the direction of John W. Cane, general foreman of the wood, foundry and plaster shop.

In a typical ACV research effort, like that being conducted with the SK-10, dozens of test programs must be carried out simultaneously. Among these: Propulsion system, lift skirt, internal subsystems, structure, aerodynamic and hydrodynamic qualities.

The craft will be put in a wind tunnel to see if its shape can be

streamlined for easier movement through air and on water. It will be checked out on static test rig that will pinpoint any area that is unstable, and its propulsion system will be run full speed against load sensors to see if it is sufficient.

One unique piece of support equipment in the lab is a flagellator, a variation of a wind tunnel in which pieces of rubber ACV skirt are flapped back and forth like a rug in a hurricane, to test their ability to withstand the pounding life of ACV work.

Similar to an open jet closed circuit wind tunnel, the flagellator is powered by a 50 horsepower motor that turns a centrifugal fan, spinning air through the circuit at nearly 300 feet per second.

To further mistreat materials that are under consideration for skirt duty, the lab has a disc abrasion-machine that can simulate a 70 mile per hour ride over sandy beach, and a "roll and fold" machine that works the material back and forth to further test its endurance.

Test specimens are bolted to the flagellator after having soaked in water. A stream of water is also in-

jected into the air while the material is flapping, to simulate a marine environment. After a set amount of time at a known speed, the specimen is compared with other specimens to see how it performed.

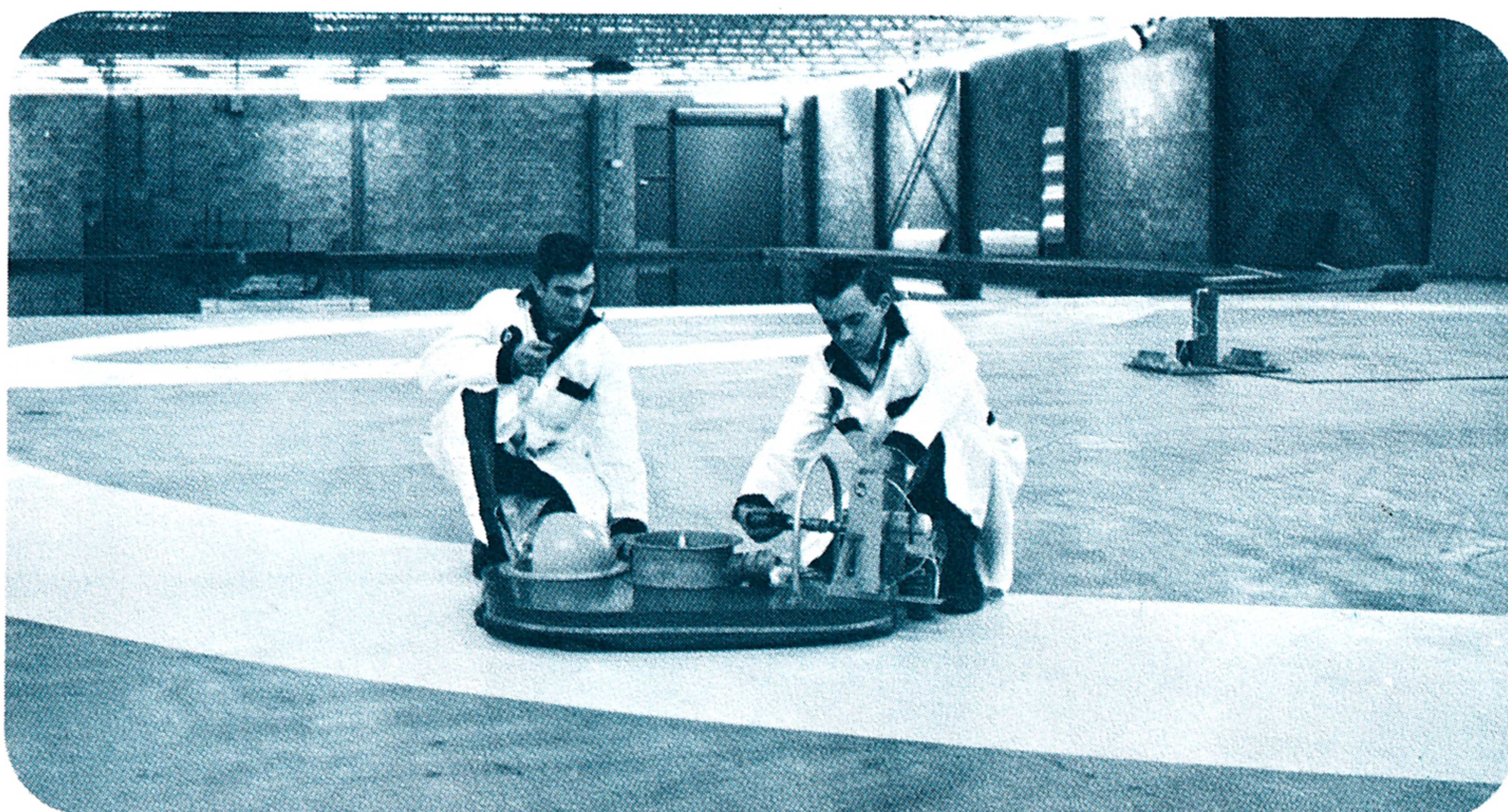
The 100-foot square maneuvering tank will handle its part of the job by giving the researchers a basin in which to confirm their analytical predictions of the maneuvering characteristics and roll stability of the SK-10.

"We know, from steady state force tests, whether a model's going to behave poorly on the water," said Griffith. "Still, there's much to learn by getting the model out there on a tether."

Motors aboard the SK-10 model are small but powerful. Installed aboard the craft's center deck, two one-horsepower motors drive the SK-10's four lift fans, and smaller motors will propel the craft from housings at each side of the center deck.

While the SK-10's motors are electric, other skimmer models often use gas engines similar to those used by airplane modelers. Some of these models are radio-controlled, so engineers can maneuver them from a tankside station.

The tethered electric-powered models receive electricity through a slip-ring system installed on a center post in the maneuvering tank. A 400-cycle variable frequency motor generator provides the power, which is controlled for scale speed by an engi-



Preparing a model of Bell's Carabao skimmer for a simulated overland run are technicians Charles W. Cronic and Thomas E. McLaughlin.

neer operating the generator output.

Before the SK-10 is put into the tank, the researchers will know exactly how much thrust it will receive from its propeller blades at a given power setting. By then, they will have tested the model's engines and its propellers on a stand that contains a swinging arm and a load cell, and they will have selected the correct propeller to duplicate the amount of thrust the full-scale SK-10 will receive from its engines at various speeds.

Another rig in the ACV Lab is the annular tank, a facility in which test models are carried by a 20-foot long "whirling arm" towing device. This

will allow the engineers to test the SK-10 at greatly-controlled speeds, attitudes and water depths.

And while the model is moving around this circular tank at speeds up to 40 feet per second, television cameras will closely monitor its performance. The TV record will be kept on tape as part of the general backlog of research information on the new ACV.

In installing the whirling arm tank, the Bell team devised a system to keep its 10-foot-wide trough of water calm, even during high speed runs. "We did it with a series of wave suppressant panels," said Griffith. "These slope into the water, and



Research version of an Air Cushion Landing Gear "skirt" is fastened to the whirling arm rig in the Bell lab's annular tank. In this tank, test vehicles are towed at varying speeds, depths and attitudes. A television camera closely monitors each test.

are padded with layers of a rubber-coated hair normally used in packaging."

The panels tend to "absorb" water movement the same way acoustical ceilings tend to soak up sound. As a result, by the time a model has sped through the full 120-foot circle, the water is calm again at the starting point.

In the whirling arm rig, the model is free to heave and pitch on its towing arm. This arm includes a balance system to measure the tangential, or drag forces, on the model. Precise steady state qualitative tests are made under this system, even though the model is not in a true zero yaw condition.

The whirling arm rig can also be fitted with a circular platform of boards, to simulate overground movements of ACVs. In the rig, the ACV's lift fan is powered, but not its propulsion system.

Working closely with Griffith in the lab are test engineers Raymond Wright and Richard Cooper, and technician Thomas McLaughlin.

"In the future, we're planning to build a linear towing tank," said Griffith. "This would further increase our ability to advance ACV technology at Bell, without going elsewhere for research facilities."

The ACV has great potential, and Bell is one of the world's leaders in the field. "This lab will help us keep that position," said Griffith. ■



A modified propeller design is examined in one of the lab's static test facilities.

SKIMMER EVOLUTION

BELL AEROSYSTEMS' LEADERSHIP IN AIR CUSHION VEHICLES IS BASED UPON THE LARGE VARIETY OF ACV's AND ACV CONCEPTS IT HAS DEVELOPED IN THE LAST DECADE.

RANGING FROM GIANT MILITARY CRAFT TO VERSATILE RESEARCH TOOLS WEIGHING ONLY A FEW THOUSAND POUNDS, HERE ARE SEVEN REPRESENTATIVE BELL ACV's:



SK-1—The largest ACV ever produced in the United States, this craft weighs 30 tons and moves at up to 70 knots over land or water. Built under Navy contracts in 1962, the SK-1 "Hydroskimmer" was part of the Navy's program to develop the technology for large amphibious assault craft.



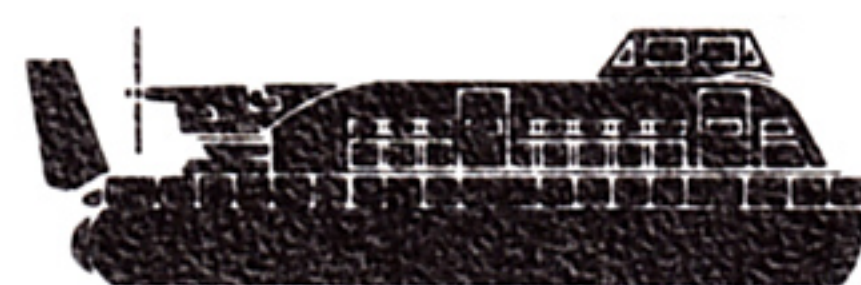
SK-3—Built with company funds in 1963, this rugged craft proved its versatility in a series of trials on Florida marshlands and ice fields in Greenland. The SK-3 "Carabao" has three circular air cushion cells powered by one lift fan. It weighs 3,200 pounds and has a top speed of 60 miles per hour.



SK-5—This is the skimmer that Bell is building for the U.S. Army and has supplied to the Navy. Based on a British design that Bell is licensed to build and modify, the military SK-5 is a swift-moving, lethal weapons platform that can pursue an enemy into swamplands and marshes open to no other vehicle. Bell's civilian-version SK-5 can handle a wide range of jobs, from passenger routes to offshore oil rig service. The SK-5 weighs up to ten tons, can carry 16 passengers and has a top speed of 70 miles per hour.



SK-6—Another craft that has potential military and civilian applications, the SK-6 at 48 feet is nearly 10 feet longer than the SK-5 and weighs 10 tons. It can carry 33 passengers at up to 65 miles per hour.



SK-9—Being developed at Bell, this craft will weigh 25 tons and will carry 91 persons or a large amount of payload. Its length will be nearly 56 feet, and it will skim at a top speed of 70 miles per hour.



SK-9B—This is the all-cargo version of the SK-9. It will have a main door opening of more than seven feet wide and six feet high, and will have a large cargo compartment capable of holding 10 tons of low-density freight. Like most of the Bell "SK" series, it will utilize many components proven in the highly successful SK-5, which has accumulated thousands of hours of operating time.



SK-10—Biggest of all Bell skimmers, this craft will weigh nearly 150 tons and will be able to carry 500 troops or 60 tons of cargo at speeds up to 80 knots. It will be a military vehicle designed to provide swift transportation for men and supplies from ship to shore and inland to debarking zones.

COMPUTERS are talking to each other at Bell Aerosystems' Electronic Data Processing Center (EDP), and the experts figure that's a good sign.

The conversations are taking place between digital and analog computers that work day and night to speed the company's business and engineering workload.

When computers talk—pass information back and forth—it's known in the industry as hybrid computation. By putting the two types of computers together, Bell gets the best both have to offer.

The digital computer is the more exact of the two. It deals in sharply-distinguishable bits of information, like the child who holds up his fingers, "digits" to help him count.

The analog computer is less precise because it works on a sliding scale principle. In this type of computer, the length of a distance on a slide, or the amount of turning of a shaft, or the amount of an electrical voltage, is analogous to the numerical magnitude that is being represented.

Paul G. Murray, who is EDP's manager of technical computation, said the analog computers backed up

by digital computers are extremely valuable to Bell for handling its various simulation tasks.

"In simulation," said Murray, "it's not necessary to have the precision you get with digital computers. Simulation is not an exact, black-or-white business."

The simulator systems at EDP can be used to study the designs and problems of vehicles which fly over the moon, in space or in earth's atmosphere. They can also be used for training pilots, or for studying problems associated with aircraft carrier landings or vertical/short takeoff and landing aircraft (V/STOL).

Computers are the key to these simulations because they take a pilot's commands—through his movements of control devices—interpret them and help produce a simulation of the effect his commands would produce in a real flight situation.

Part of the simulation is visual. Bell uses stereo television projectors for this, with operators wearing special glasses to see their flight environment in three dimensions. A Bell simulator unveiled two years ago was the first to provide three dimensional projection.

In an article titled "Flying by the

Seat of a Computer," the February, 1965 issue of *Rendezvous* described how a versatile computer system had been developed at EDP for letting Bell's test pilots fly a simulated X-22A experimental V/STOL aircraft.

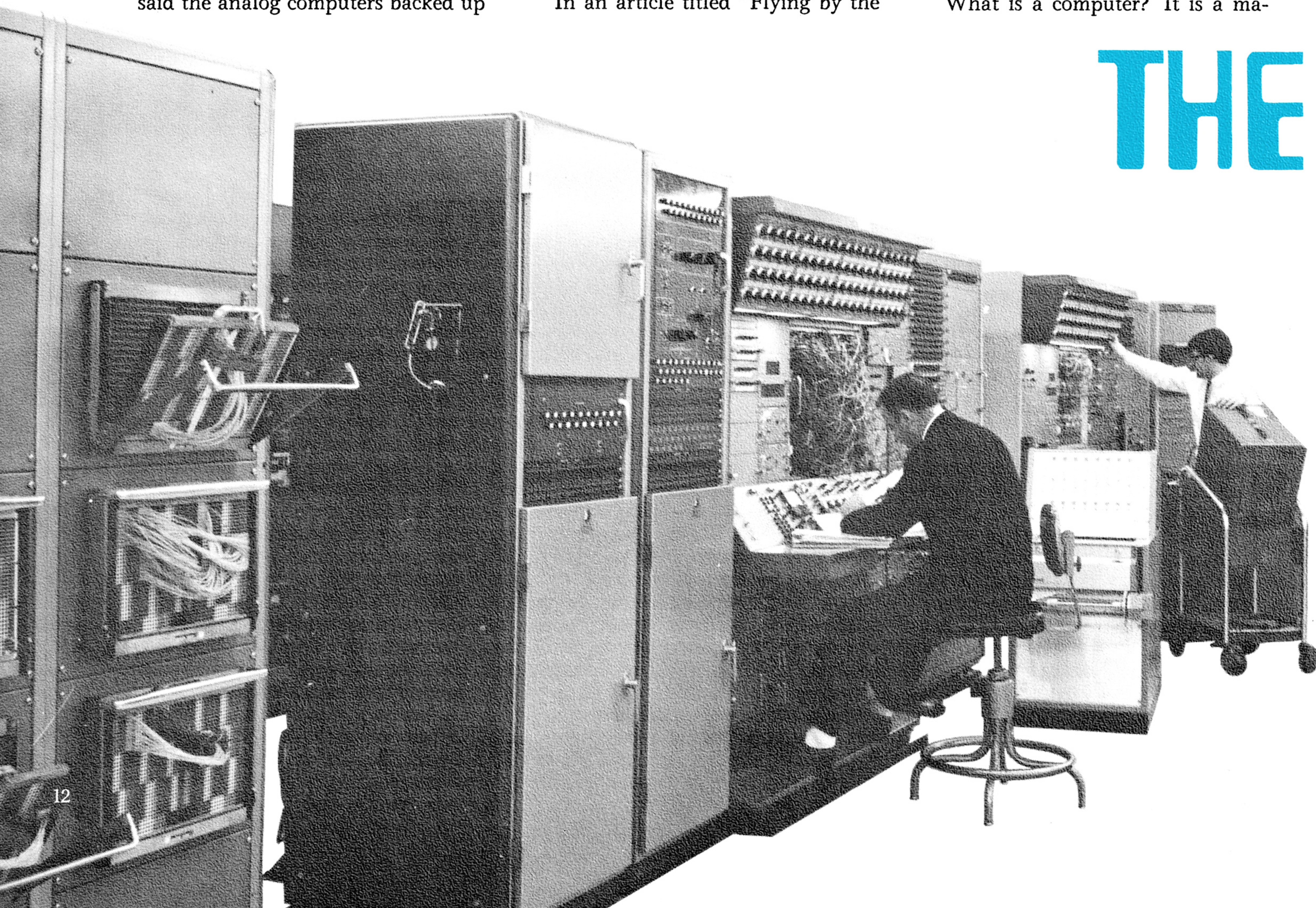
That simulation and the others are conducted in a darkened room or a simulated cockpit, where the operator has access to the appropriate controls for maneuvering his vehicle in response to a scene projected before him on a 10 by 14-foot screen.

For a simulated rocket-propelled flight over the moon in a lunar flyer, the lurain is projected before the operator. This scene is transmitted by a television camera that "flies" over a scale relief map of the moon in an adjoining room.

As the pilot flies in simulation, the picture in front of him changes according to his commands. Electronic signals to his craft cause it to pitch appropriately. Simultaneously, signals go to the cockpit instrument panel to indicate velocity, altitude, attitude, time and fuel consumption.

But this is only part of EDP's simulator capacity, and computer time spent in simulator work is only a fraction of the facility's work load.

What is a computer? It is a ma-




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0 1 0 1 1 1
      0 0
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chine that can carry out a sequence of mathematical or logical operations on data, which is usually fed to the computer in the form of numbers.

Sometimes called an "electronic brain," the computer is actually brainless: it can do its job only as long as some hard-working human programmer tells it, step by step, how to go about its business. Ralph G. Swanson, who is EDP's manager of business programming and systems support, explained just how detailed these instructions have to be.

"Here's a simple program," he said, pulling a large stack of folded paper out of his desk drawer. On the paper were more than 400 instructions — many of them the kind of commands that an outsider to computers might think the machine would not need.

"Take this one, for example," said Swanson, pointing to a small group of letters and numbers. "This tells the computer something about the layout I want for the printed report. It tells the computer to put six spaces between words at the top of the page. Without that command, the words would run together."

The immensity of man's job in getting the computer to perform prop-

erly is only faintly indicated by that one example. In a large program, thousands of similar details have to be explained to the computer.

And the program is not the end. A program, for experts working on a major problem, is only part of an overall system. A major system, like the one used at Bell for marketing studies, contains dozens of programs and prints a large number of reports.

"The building blocks have all got to be there," said Swanson. "When they are, the computer is a marvelous tool for solving problems."

Raymond E. Carroll, EDP director, said a great many problems of handling information are completely beyond the powers of human beings to solve, but are entirely within the powers of computing machines. Speed of handling information, accuracy and reliability are the basic assets of computers, he said.

Considering this, it is remarkable that the basic structure of a digital computer is really simple. It has six essential parts, as follows:

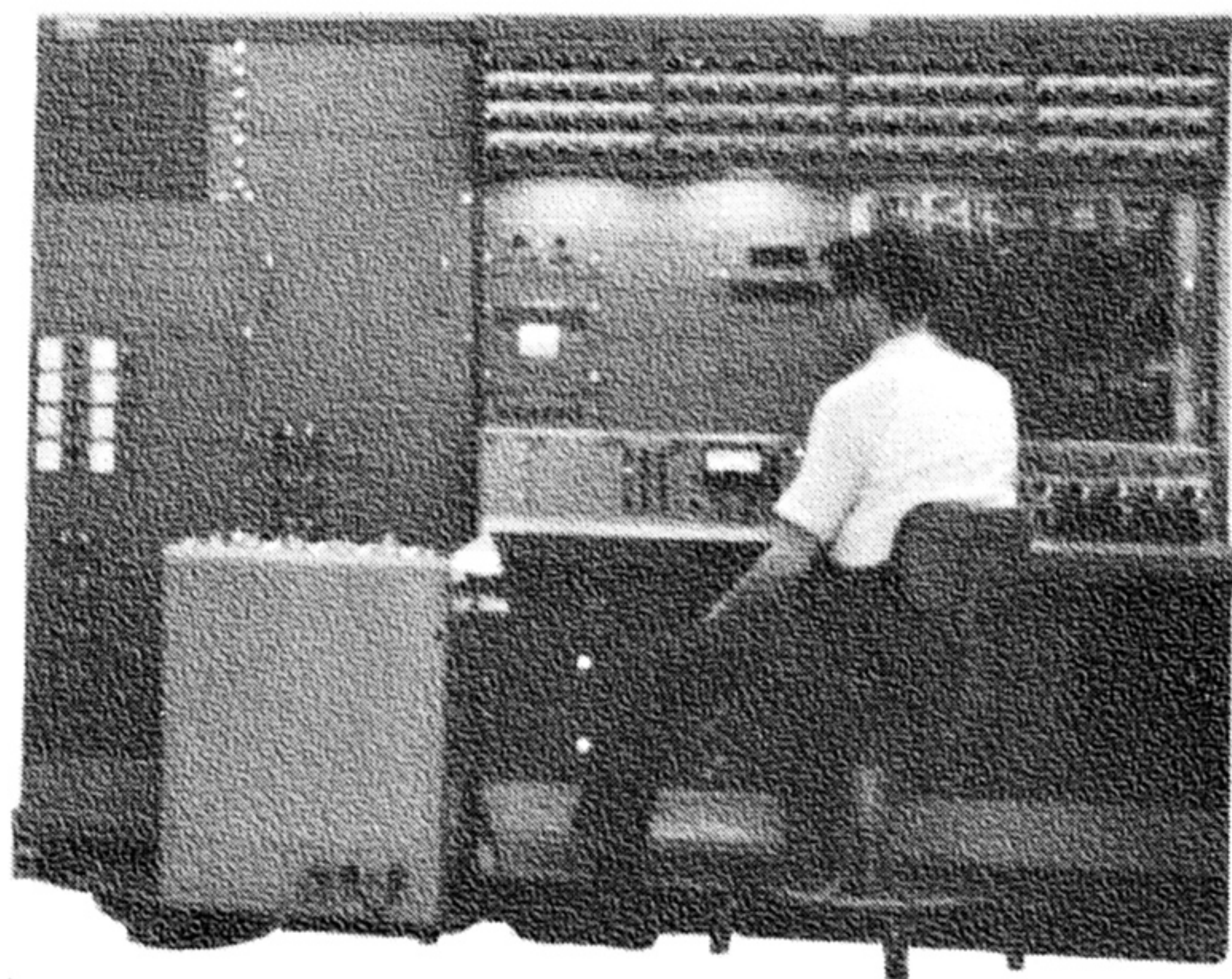
The *input unit*, which takes in numbers, other data and instructions, which are prepared in acceptable machine language. (Swanson's program, for example, was prepared on

DATA PROCESSORS

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0 1 0 0
1 0 1 1 1 0 0
0 0

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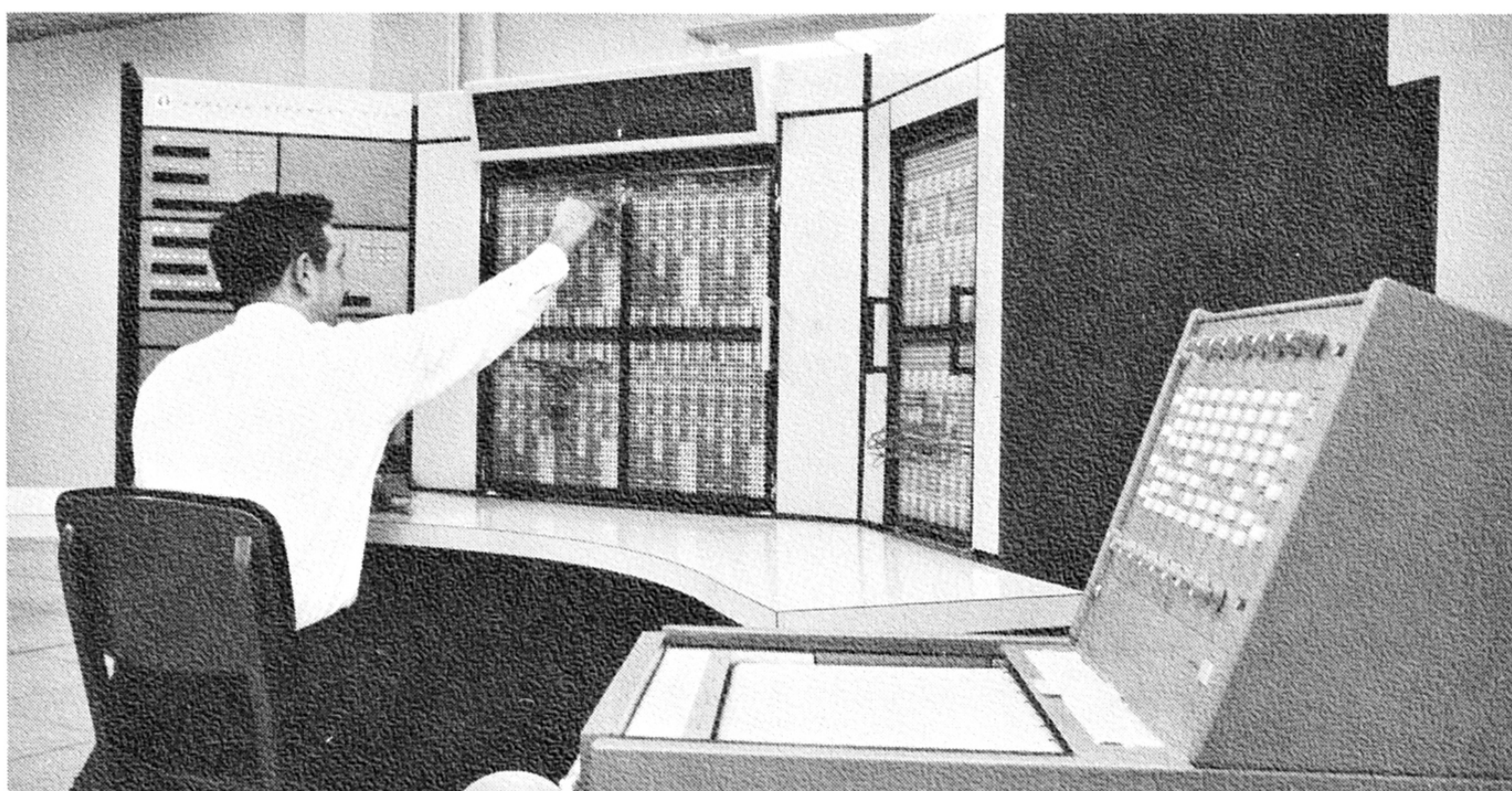
by Don Norton

Computers talk to each other at Bell's Electronic Data Processing Center, as the company increases its capacity for solving problems through computer know-how.

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0 0 0 1 1
1 1 0 0 0 0
1 1 1 1 0
0 0 0 0
1

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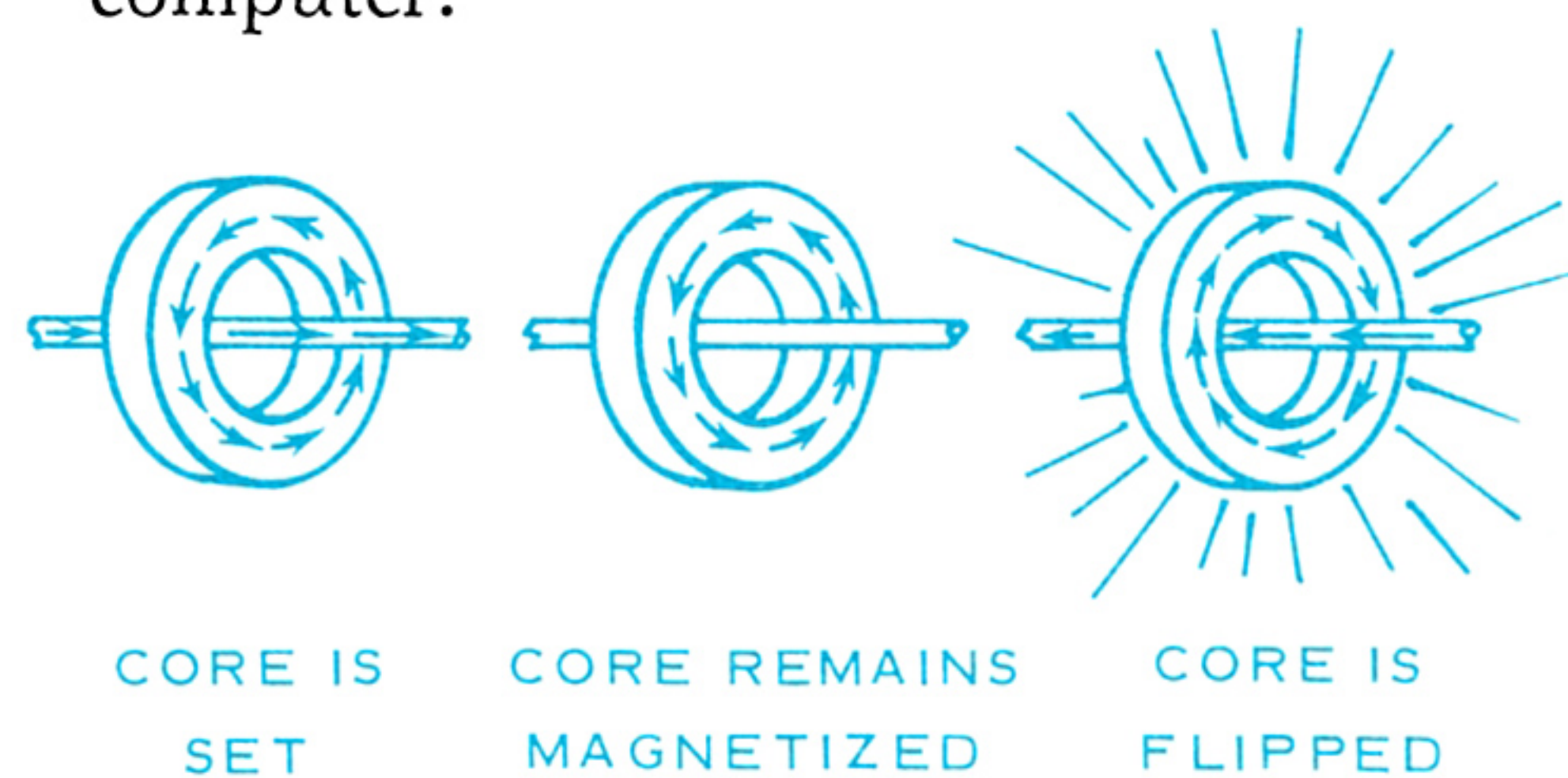
An analog computer is adjusted by engineering assistant Ralph L. MacVittie.

cards punched with holes. Another form of machine language is polarized spots on magnetic tape.)

The storage, or *memory unit* which contains thousands of units where bits of information or instructions can be stored, in machine language. The main storage medium for many computers is the magnetic core, which is a ring of metal with a wire running through its center.

An electric current passed along this wire sets up a magnetic field which magnetizes the metal ring. When the current is removed, the core remains magnetized, and when the current is sent through in the opposite direction, the magnetic field in the ring is reversed, or "flipped."

To read the status of the core, a second wire runs through the ring. This wire receives a small electrical current when a core flips, and this "message" is passed along to the computer.



Magnetic Core Action

This two-way street is the key to the computer's memory. As with the magnetic core, all computer elements are able to represent two states. These two distinct states provide the

basis by which these elements hold information. For this reason, the elements are called bi-stable elements.

In computers, it is in patterns of core states, or ones (for one direction of the electrical flow in the magnetic rings) and 0s (for the opposite current).

These patterns represent the digits 0 to 9, the letters A to Z and certain other characters, such as the dollar sign and punctuation marks. Each character is expressed as a code of ones and 0s. The binary scale may be used for the digits 0 to 9, with the result that these digits are coded as follows:

0 — 0000	5 — 0101
1 — 0001	6 — 0110
2 — 0010	7 — 0111
3 — 0011	8 — 1000
4 — 0100	9 — 1001

The *arithmetic unit* of the basic computer performs addition, subtraction, multiplication, division, and the other arithmetical and logical operations on numbers it receives from storage, and can send the result of the operation back to storage.

The *output unit* takes computed answers in machine language and translates them into printed characters on paper.

The *buss*, or trunk, uses wires to convey information from one part of the machine to another.

The *control unit* takes in each successive instruction from the memory unit and issues commands to the switches or gates inside the machine.

Bell's EDP has four digital computers from the IBM System 360 line, considered among the most advanced in the world. They are put to work in the design and testing of rocket engines, and perform "housekeeping" chores, like computing and printing the weekly paychecks for Bell's 7,300 employees.

Another of Bell's large digital computers is the IBM 7090, which works with analog computers in simulation work, does scientific calculations, controls inventories and keeps track of production.

Besides the Agena rocket engine, Bell is building and testing the ascent engine that will lift U.S. astronauts from the surface of the moon, and liquid rocket motors for the post boost propulsion system of the Minuteman missile.

One 240-second test of a rocket engine, for example, may produce as many as 1.7-million measurements of such factors as temperatures, pressures and fuel flow. And a performance reading may be required for each 1/10th of a second.

Two of the System 360 Model 44 units are being used for such tests. One is located in the Rocket Test facility at Bell Wheatfield, and the other is at Bell Test Center, near Lewiston.

"The largest and most powerful digital computer on the Niagara Frontier is Bell's System 360 Model 65," said Murray. "It is the work-horse computer of the company."

Murray said the Model 65 is a "remarkable computer," with a memory unit of 512,000 "bytes" (each byte being equivalent of about one character), and external storage devices capable of transmitting data to and from the memory unit at the rate of hundreds of thousands of characters each second.

Connected to a System 360 Model 50 at EDP are 18 Remote Access Computer terminals (RAX). These typewriter-like terminals are placed at intervals throughout the Bell Wheatfield engineering area, for convenient use by engineers in solving problems on the spot.

There is one RAX terminal doing business with EDP by long distance. It is located in Bell's Cleveland, Ohio plant. Engineers there dial long distance to go on-line with EDP.

Some chuckles developed because of this long distance tie-in. A tele-

phone had to be installed at EDP to receive Cleveland's computer calls. All "local" RAX communications go directly to the computer.

"That phone had to be taped down," said Murray. "Too many people absent-mindedly picked up the receiver when they heard it ring."

By picking up the telephone, the connection between the engineer and the computer was broken, and he had to dial again.

The RAX system, however, is only one of the many ways EDP is called upon to solve Bell Aerosystems problems. Many problems come through the door, in the hands of engineers or managers who need help.

Scientists and engineers who bring in computational problems are normally directed to senior digital analysts, who work with them to develop a working definition of the problem to be solved. With this definition, the senior programmer works with junior personnel to develop methods of solution: Numerical algorithms and "bookkeeping" schemes.

At this phase the problem is put into the computer, and a long process of "check-out" is followed. In check-out, the programmer makes certain that the computer performs all the operations necessary to correctly calculate the desired solution. This phase of the operation is extremely difficult, since it utilizes the computer to perform calculations beyond the scope of the slide-rule and desk calculator.

When a major new computer-oriented business system must be developed, it is done cooperatively by EDP and Management Information System (MIS), a division of the Management Engineering Department. Usually a team is formed, putting together an MIS analyst, a senior EDP programmer and the managers of the departments involved.

"Preliminary investigations and detailed planning for a major system can take many months," said Swanson. "Programming cannot begin until this definition phase has been completed."

To be of use, a new system must be tailored to the particular problems encountered at Bell. "Systems are redesigned as the company grows and changes," Swanson said, "and as our increasing computing capability enables us to provide services that previously were not possible." ■

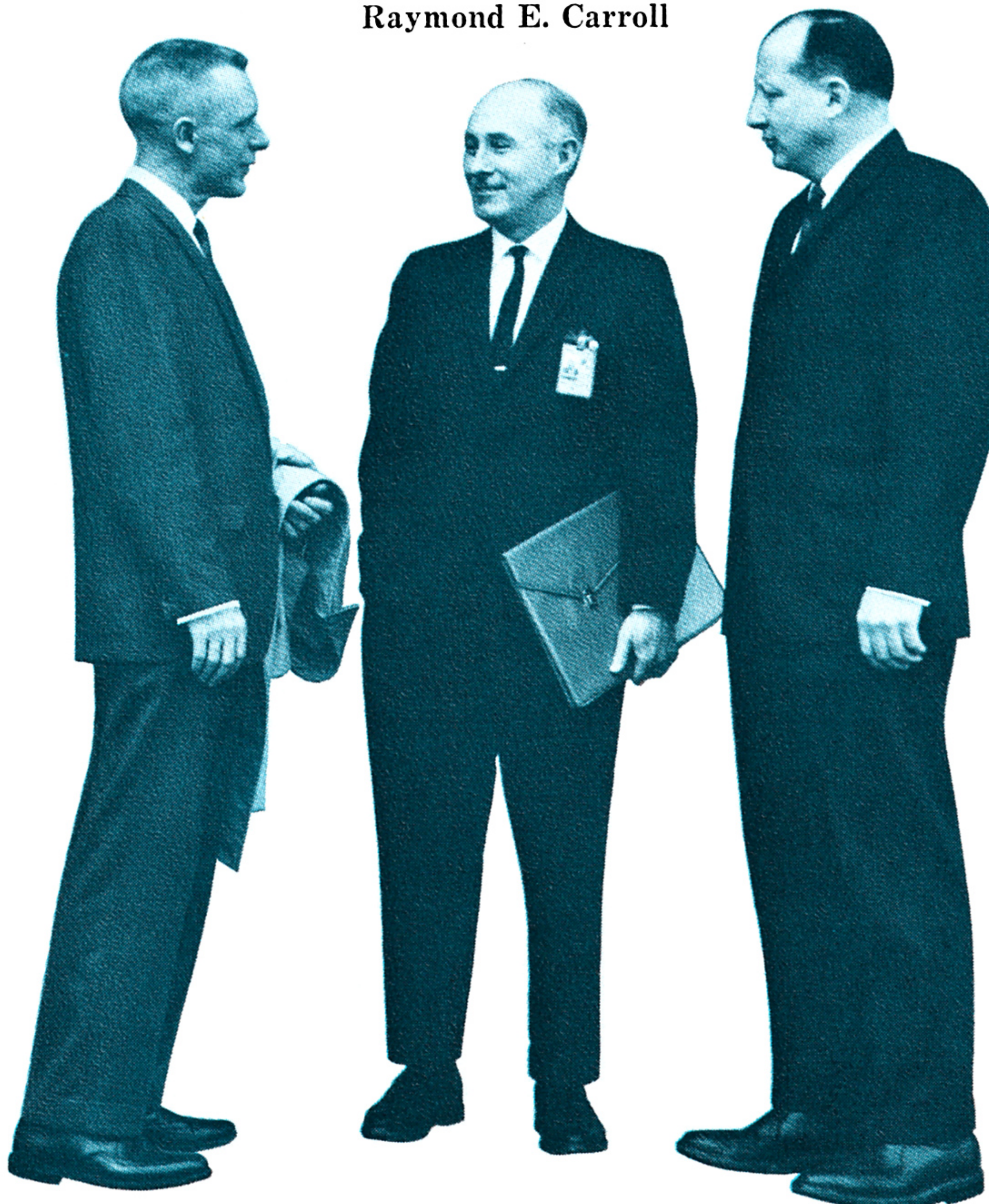


Bell's giant IBM System 360 computer occupies a place of honor in the data processing center. Its tasks range from printing paychecks to solving questions generated by engineers in advanced research.

Ralph G. Swanson

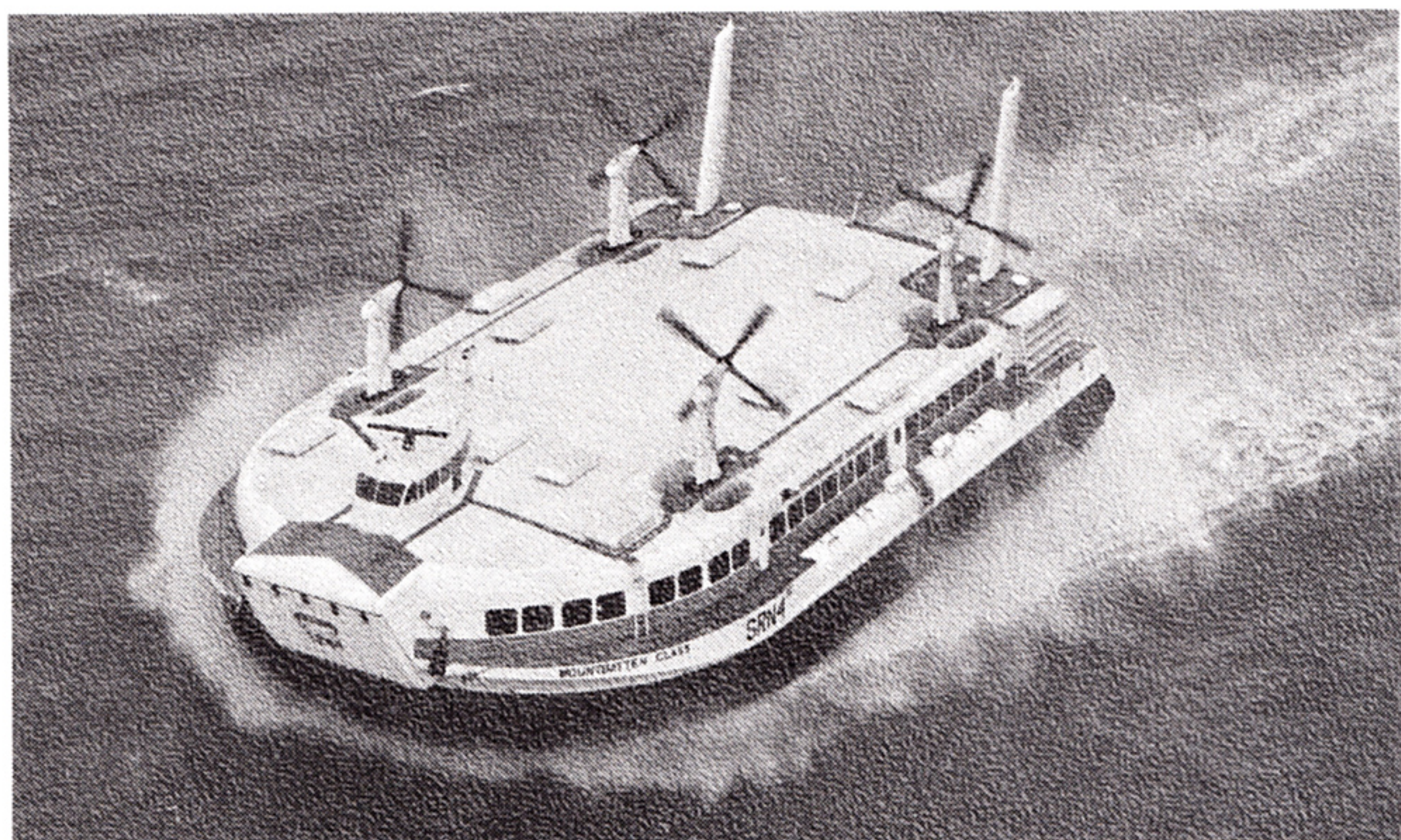
Paul G. Murray

Raymond E. Carroll



AEROSPACE REPORTS

TRULY A GIANT among ACVs is British Hovercraft Corporation's new SR.N4. Weighing 165 tons, the standard craft will carry 254 passengers and 30 automobiles. An all-passenger model could carry 609 persons. The initial SR.N4 service on the English Channel is expected to begin this summer.



UNDERSEA MINING showed substantial growth in 1967. New mining companies were formed, existing small companies became more active, and some major corporations decided to try marine mining. The payoff will come in future years. It takes about four to six years to find, develop and produce from a new property, land or undersea.

ENGINEERS MEASURED 2,894 performance parameters of the Saturn V rocket during the Apollo 4 flight last Nov. 9. This compares with 75 measurements taken on the Redstone launch vehicle which boosted Alan Shepard into space on May 5, 1961.

PLANET JUPITER'S huge red spot may be red organic dye, according to two researchers at the Ames Research Center of the National Aeronautics and Space Administration. Dr. Cyril Ponnampereuma and Fritz Woeller found that electrical discharges sent through a simulated Jupiter atmosphere of ammonia and methane produced an organic dye stuff, with a ruby red translucency. This dye could be pushed up through the planet's dense white clouds by a vortex in the atmosphere caused by a giant meteor crater on Jupiter's surface, they said.

MOTION STABILIZED gravity meters are being delivered to customers at a rate of one a month this year by Bell Aerosystems Company. The first was delivered in January to the U.S. Army Mapping Service, and others will go to the U.S. Navy's Oceanographic Office, the Gulf, Shell and Mobil Oil companies. The meter, known as the BGM-2, can make extremely accurate gravity readings from a moving ship.

DEVELOPMENT OF RASS, a radar attitude sensing system, will be continued by Bell Aerosystems under a \$289,867 contract from the National Aeronautics and Space Administration's Manned Spacecraft Center. A multi-purpose flight control sensor, the system uses radar to tell astronauts their altitude, rate of pitch, roll and yaw, and horizontal and vertical velocities.

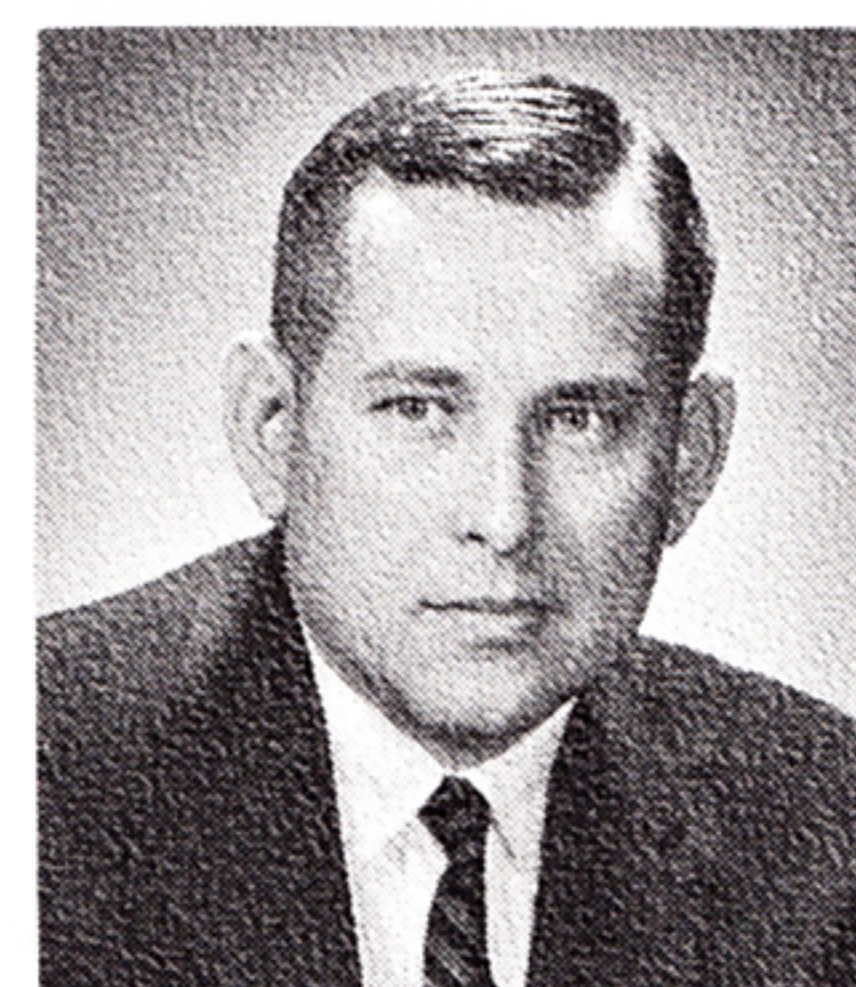
PHENOMENAL GROWTH of the U.S. transportation industry is reflected in these recent government statistics: About 20 per cent of the gross national product in 1965, more than \$140-billion, was spent directly or indirectly on transportation. About 14 per cent of the work force, 9-million persons, work in businesses related to transportation. Transportation provides \$21-billion, or 19 per cent, of the total federal tax revenue.

A NUCLEAR BLAST 3,200 feet underground last January hit seismographs 1,700 miles away with the intensity of an earthquake. The explosion, equivalent to nearly a million tons of TNT, was conducted by the Atomic Energy Commission at Hot Creek Valley in central Nevada.

THREE APPOINTMENTS have been announced by President William G. Gisel at Bell Aerosystems. . . . Dr. Clifford F. Berninger was named vice president of research. A member of Bell's Scientific Advisory Committee, Dr. Berninger joined the company in 1967 as assistant to the president. . . . Charles F. Kreiner was named director of public relations and advertising. Associated with Bell in various public relations assignments since 1961, he succeeds G. Jackson Butterbaugh, who died last Feb. 2. . . . William M. Smith was named assistant to the president in addition to his duties as chief scientist.



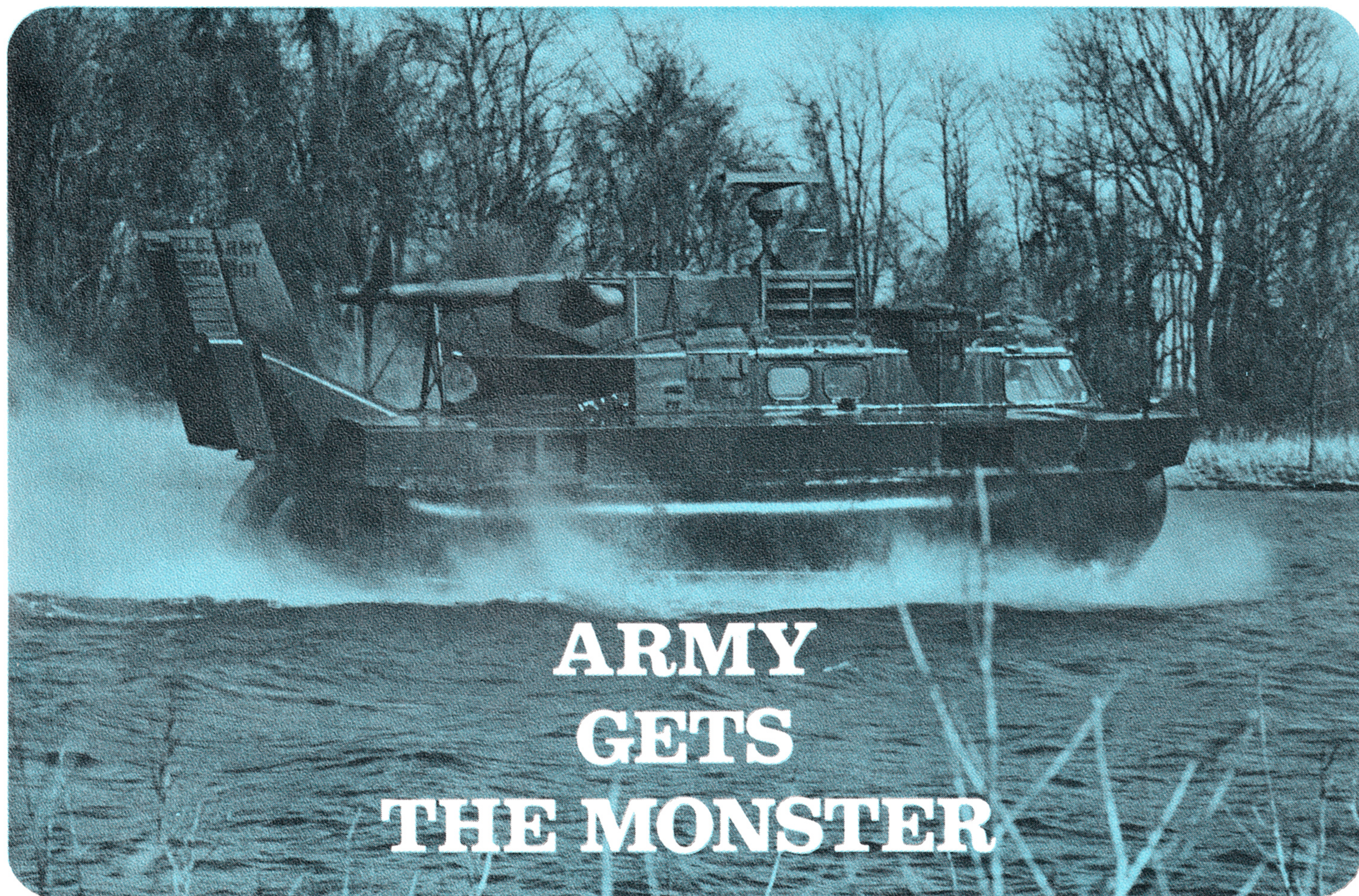
Dr. Berninger



C. F. Kreiner



W. M. Smith



ARMY GETS THE MONSTER

THE “float like a butterfly . . . sting like a bee” metaphor once reserved for a well-known boxer may become the label for another high-speed heavyweight — the U.S. Army’s new SK-5 Air Cushion Vehicle (ACV).

Major David G. Moore, the veteran armor officer commanding the Army’s first ACV unit, refers to its emergence as “. . . a revolution in ground mobility and mounted combat.”

The 10-ton armored amphibian, which can skim over and through coastal marshlands as well as mud and rice paddies like a feather-light waterbug at speeds in excess of 60 knots, delivers a much greater punch than any previous member of Bell Aerosystems’ growing family of military ACVs. Perched on its port side is a bow-mounted grenade launcher, and machine guns of varying calibers bristle from the craft’s cabin and twin roof turrets.

Bell has built three SK-5s for the Army. Two are Assault Air Cushion Vehicles (AACV); the third, a Transport Air Cushion Vehicle (TACV) which has everything but the grenade launcher. The three are the first to roll off Bell’s new quantity production line and the first built exclusively in the U. S. to military specifications. They also represent the Army’s first combat ACV buy.

Three earlier Bell craft, which have been on a second combat tour in Vietnam since October as U. S. Navy patrol (PACV) vehicles, are commercial ACVs modified to meet Navy needs. Consequently they are not as heavily armed or armored. They have, however, proven the ACV’s ability to perform a variety of missions,

including amphibious assaults, search and rescue, high-speed troop/cargo transportation or patrol and logistic support.

In addition to its armor and extra firepower, the Army’s SK-5s feature a more powerful turboshaft engine, puff ports and finger skirts to increase craft control and maneuverability at low speeds, an enlarged cabin door which can handle a jeep-size vehicle, a self-contained auxiliary power unit and the use of corrosion-resistant aluminum in those areas of the craft susceptible to corrosion.

Also, the curved side decks of the earlier Bell ACVs have been replaced by higher strength flat decks which can be utilized as walkway or stowage areas.

Commenting on the ACV’s abilities, Lt. Col. Carmen P. Milia, Air Cushion Vehicles Project Officer for the Department of the Army, stated recently:

“It (the ACV) can carry more for a longer period of time — and then fight! When it gets to where the fight is, it can stop, set down on land, swamp or water and fight indefinitely. Unlike a helicopter, it has an unlimited loiter time and does not have to return to base. With a share of armor protection to protect the critical areas, the ACV is able to give a good account of itself in a scrap.”

There, indeed, has never been any other piece of Army hardware quite like the SK-5. During its intensive combat test in the Mekong River Delta region in the ensuing months, the Viet Cong will soon learn how well this new “monster” combines butterfly finesse with the sting of a bee.



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